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APPLICATION

FOR

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**TITLE: ESTABLISHING COMMUNICATIONS BETWEEN
DEVICES WITHIN A MOBILE AD HOC NETWORK**

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ESTABLISHING COMMUNICATIONS BETWEEN DEVICES WITHIN A MOBILE

AD HOC NETWORK

Background

This invention relates generally to communication
5 systems and particularly to establishing links between
individuals on a wireless communication network.

A mobile ad hoc network (MANET) is an autonomous
system of mobile routers and associated hosts connected by
wireless links, the union of which forms an arbitrary
10 graph. The routers are free to move randomly and organize
themselves arbitrarily. Thus, the MANET wireless topology
may change rapidly and unpredictably. Such a network may
operate in a stand-alone fashion or may be connected to a
larger Internet.

15 A MANET consists of mobile platforms called nodes that
are free to move about arbitrarily. MANET nodes may be
equipped with wireless transmitters and receivers using
antennas which may be omnidirectional (broadcast), highly
directional (point-to-point), steerable, or some
20 combination thereof. Generally MANETs are bandwidth-
constrained variable-capacity links. Often the nodes are
energy-constrained since they may be portable and rely on
battery power.

An implicit assumption within a MANET is that every node within the network may wish to communicate with every other node within the network. The MANET protocol defines all devices as routers, and then goes about trying to 5 comprehend how each router maintains real time knowledge about the existence of other routers within the network. This becomes an exponential task to manage as the network increases in size. This problem is compounded by the ability of the nodes to dynamically enter or leave the 10 network in an "ad hoc" fashion. The ad hoc nature of the network creates an onerous network management problem, flooding the network with status packages requiring constant updates.

There are a number of postulated causes for MANET 15 network failure. The network updates may not be received fast enough to keep up with dynamic changes. The information about which nodes are currently connected to the network may become so out of date that it is no longer trustworthy. The network updates may consume so much of 20 the available bandwidth that there may be insufficient residual bandwidth for actual data to traverse the network. The battery life of each node may be insufficient because of the volume of update traffic, which requires the node to be almost permanently communicating with other devices in 25 order to obtain network status information. A routing table that contains the information about how to traverse

from one node to another may become so large that it may not be stored in the available memory capacity of nodes within the network.

Thus, there is a need for better ways to manage a
5 mobile ad hoc network.

Brief Description of the Drawings

Figure 1 is a schematic depiction of a mobile ad hoc network in accordance with one embodiment of the present invention;

10 Figure 2 is a block depiction of a node in a mobile ad hoc network in accordance with one embodiment of the present invention;

Figure 3 is a flow chart for software in accordance with one embodiment of the present invention; and

15 Figure 4 is a flow chart in accordance with another embodiment of the present invention.

Detailed Description

Referring to Figure 1, a mobile ad hoc network (MANET) may be established between a plurality of mobile devices, 20 such as the devices X, Y, Z and A. Each device X, Y, Z and A may be a wireless transceiver. The wireless transceivers may use any available wireless protocol including the Bluetooth specification (Specification of the Bluetooth System, Version 1.1, February 22, 2001) and 802.11 25 specification (IEEE Standard 802.11 available from the

Institute of Electrical and Electronics Engineers, New York, New York). In some embodiments they may be mobile battery powered devices. Each device generally has a limited range indicated by the dashed circles.

5 Instead of trying to communicate with every single device in the network, which commonly may be a very large number of devices, a network is established with a smaller group of devices within the network. Each device includes a contact list. A contact list may be a list of
10 individuals with whom the device has communicated in the past. Contact lists are commonly stored on computers. For example, on Microsoft Explorer[®], contact lists may be maintained. Similarly, lists of addressees may be maintained with a variety of software including scheduling
15 and information management software. Thus, each device X, Y, Z or A in this example, may have its own contact list.

In order to establish a network, each of the devices may exchange its contact list with any in-range devices. For example, the devices X and Y are both in-range and may
20 exchange contact lists. Each device X or Y may then determine, in one embodiment, whether they may have common entries on their contact lists. This common entry information may be stored. Thereafter, the devices Y and Z may exchange contact lists and determine which devices are
25 in common on each of their contact lists. In addition, the device Y may store information about which contacts on Z's

contact list are also on X's contact list. The devices Z and A may then exchange contact lists and a determination may be made about what are their common contacts. Z may also determine which contacts on A's list are also on Y's

5 list.

Thus, as shown in Figure 1, the device X's contact list includes at least Y. The Y's contact list includes at least X and Z and Z's contact list includes at least Y and A. Finally, A's contact list includes at least Z.

10 In accordance with one embodiment of the present invention, a MANET may be established within a smaller defined group, which is therefore much more manageable. The smaller defined group may be established by exchanging contact lists and establishing communication links from a

15 first station, such as the station X with other stations which may or may not be in-range, but are determined to have common contacts in their contact lists. Thus, even though the device Z is out-of-range from the device X, the device X may establish a communication link through their

20 common contact Y, to out-of-range device Z and ultimately to out-of-range device A.

Devices determine which common contacts they have and this common contact information may traverse the network as the network grows over time. This common contact

25 information may be stored in a routing table, which in one embodiment may be available on each device within the

MANET. Also, stored is information about whether or not a particular device is currently on-line.

In some embodiments, still additional profile information may be transferred and stored, such as the 5 device's identifier, a profile of personal information about the device owner, alternative routes to each device on-line, and identifying adjacent devices for a first hop and the number of hops to the destination device. Also, stored in some embodiments, may be information about the 10 type of each device, such as whether it is an audio, text, phone, still picture capable device, and the like.

This shared information may traverse across the network as well as being progressively exchanged between in-range devices. As status information changes, for 15 example, whether or not a given device is on-line or not, that information may be shared around the network.

A device 10 such as one of the devices indicated as X, Y, Z or A in Figure 1 may include a controller 12 as indicated in Figure 2. The controller 12 may communicate 20 with a wireless interface 14. It may also communicate with a storage device 16 that stores the communicate software 18 and the network software 20 in accordance with one embodiment.

The network software 20 shown in Figure 3, in one 25 embodiment, begins by identifying and storing in-range devices as indicated in block 22. This in-range device

information may be stored in a routing table stored in the storage 16 in one embodiment. Next, common contacts between in-range devices are determined. This may be done by exchanging common contact lists, identifying contacts 5 that are common, and storing that information in the routing table as indicated in block 24.

The common contacts determined between a first set of devices may then be shared with other in-range devices that are common contacts as indicated in block 26. The mutual 10 common contacts are then stored in the routing table.

Next, the mutual common contacts, whether they are in-range or not, are stored in the routing table as indicated in block 28. The out-of-range common contacts may be obtained by the progressive sharing throughout the 15 network of information of common contacts between devices that are in-range. Eventually this information reaches out-of-range common contacts.

Finally, the status information for each device in the network of common contacts is stored. This status 20 information may include whether a particular device is currently active or available for receiving communications and that information is similarly shared with in-range common contacts, eventually reaching out-of-range common contacts as indicated in block 30.

25 Thus, through the sharing of information between common contacts, the nature of the network and the status

of each device in the network may be dynamically updated on an ongoing basis. As soon as one device is determined to no longer be active, that information may be gleaned by in-range devices that share the information with in-range 5 devices until the information eventually progresses throughout the network. Because the common contacts determine a more workable number of devices, the MANET management becomes more workable. By establishing a MANET of manageable size using common contacts, a more efficient 10 network may be achieved especially because of the likelihood that the common contacts will want to contact each other anyway. In other words, a MANET of manageable size is achieved among individuals who are likely to contact each other anyway, avoiding the storage of 15 connection information between devices that are less likely to communicate with one another.

The communicate software 18, shown in Figure 4, begins by identifying a recipient of a potential message as indicated in block 32 in one embodiment. A check at 20 diamond 34 determines whether the intended recipient is in the routing table. If so, a check of the status information (diamond 36) associated with the intended recipient determines whether or not the device is currently active. If not, an error message may be generated as 25 indicated in block 42.

If the device status is okay a message may be transmitted to the recipient via a series of in-range devices over a path that was stored in the routing table of those devices, as indicated in block 38. If an intended 5 recipient is not on the routing table, an error message may be generated as indicated in block 40. This means that the device is both not in-range and not a common contact with a series of devices that can define a plurality of in-range links to that device.

10 While the present invention has been described with respect to a limited number of embodiments, those skilled in the art will appreciate numerous modifications and variations therefrom. It is intended that the appended 15 claims cover all such modifications and variations as fall within the true spirit and scope of this present invention.

What is claimed is: